Optical Harness for Space

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Abstract: Optical harness procurement for space applications requires a good understanding of optical harness components. This white paper describes the component of such a harness and propose a systematic approach for procuring parts depending on individual space project situation. As a valued player on this market, Diamond present its implementation of such approach through products and quality grade concerning connectors and termination.

1 Introduction

Optical harness is used in space vehicle to transmiss digital or analog information for data or sensing functions. The reliability of the components and the harsh environment they are submitted to require a systematic and careful approach when planning and procuring such a harness.

This white paper aims at helping understand the various components composing such a harness.

Due to Diamond speciality, emphasis will be given to the connector and termination process.

2 Optical harness

An optical harness consists of a series of patchcords and pigtails carrying optical signal from a source to a target, including adapter, free space half-adapter (KST) and optical modules (isolators, couplers,…).

We'll leave discussion of the optical modules outside the scope of this white paper and focus on the basis components : fiber, cable, connector and adapter.

2.1 Telecom approach

The telecom has edited standards for each of these components as describes below. The aim is to make sure every manufacturer produce according to the same requirements.

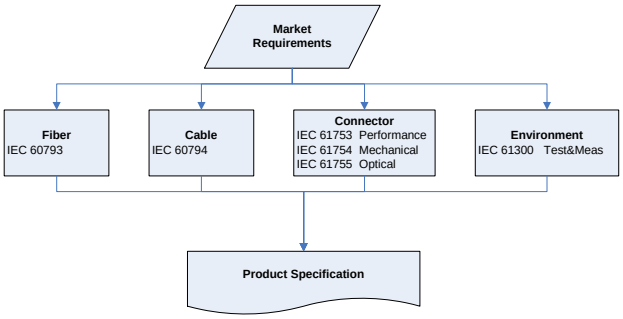

fig. 1 Telecom standards

2.2 ESA ECSS approach

The approach done by ESA has a somewhat different goal. In the ECSS approach, there exists three types of specification: Generic, basic and detailed.

The aim is to describe how a device (patchcord) should be qualified for space application and standardized it when necessary (detailed specification).

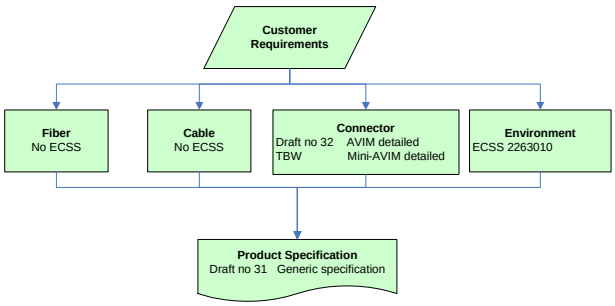

fig. 2 ESCC specification and standardization approach

2.3 Optical Harness components

2.3.1 Fiber

The fiber is the element that transmit the light and it's type depends on the user's application. Various type exists, among the most common we'll cite the multimode (MM), singlemode (SM) and polarization maintaining (PM).

The space application add the complexity of temperature, but more important, irradiation to the fiber. Irradiation increase glass absorption, which induce an increase in loss.

Picking the right fiber for the application is the user responsibility. Diamond is not qualified to make the choice at this point, but Diamond should be involved in the choice of the fiber in order to assert its influence on the termination procedure.

A good source of information here is NASA GSFC Photonics group website at

http://photonics.gsfc.nasa.gov .

2.3.2 Cable

The cable is normally used for protecting mechanically the fiber. This mechanical protection usually interfere with the thermal behaviour and is the normally the result of a trade-off between those two effects.

So far, besides using un-protected fiber, we found the most successful solution to be using an ePTFE covered fiber with Kevlar® aramid strength member and fluoropolymer jacket. Other solutions using PEEK loose tube have been successfully implemented too.

The cable structure has usually a large impact on termination procedure and final performance, Diamond should be involved in the definition of the cable.

2.3.3 Connectors

The connectors warrant a good physical alignment and contact between two fibers in order to have no discontinuity in the glass light guide.

Their properties to resist to the environment (surviving launch, space environment and sometimes planetary landing) are important.

Diamond products are presented below.

Two connectors are proposed for evaluation and qualification unders ECSS standards, the Mini-AVIM and AVIM connectors. The end of the program, anticipated by Q1 2012 should see the finalization of two detailed specifications.

3 Purchasing procedure

Diamond has identified three principal phases and as such propose three types of quality grades.

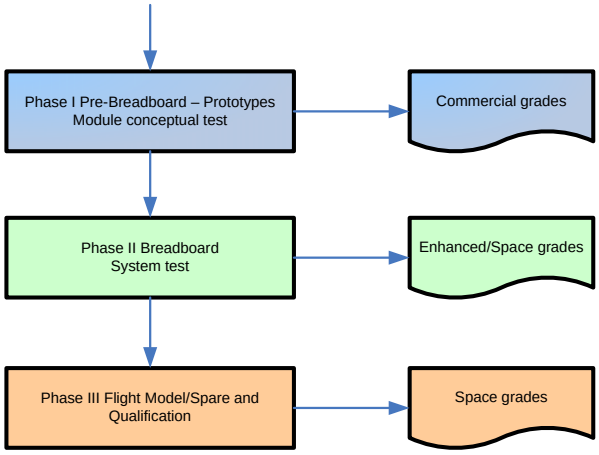

fig. 3 Project phases

At this point, there are no standards for optical harness components, some are in preparation but due at the earliest in Q1 2012.

As such, the harness must be qualified each time.

Diamond at this point propose termination services, testing/qualification services and consulting which corresponds to its expertise.

We expect, through our effort in the Evaluation and qualification work done under ESTEC contract to simplify the requirements for purchasing.

4 Diamond products

Diamond is a well known optical connectors developper and producer. The company was born in 1958, works and leads the optical connector high quality market since 1980s.

Resources on involved mission can be found on our website.

4.1 AVIM

The AVIM connector was develop for an avionics application in the early 90's and has since then survived several space mission. It is present on the space shuttle and planned on various space mission.

This connector has been used in other harsh environment application.

fig. 4 AVIM connector and mating adapter

full specification can be found on Diamond website at

http://www.diamond-fo.com/en/markets_space_avim.asp

4.2 Mini-AVIM

The Mini-AVIM is a recent adjunct to our space catalog and has been developed as a lighter smaller version of the AVIM. It contains the same ferrule and locking mechanism principle with a smaller package realized entirely in Titanium

fig. 5 Mini-AVIM connector and mating adapter

full specification can be found on Diamond website at

http://www.diamond-fo.com/en/markets_space_miniavim.asp

4.3 DMI-Space (Q1 2011)

The DMI-Space is a recent adjunct to our space catalog. It has been partially tested by NASA and will be released by Q1 2011. It is a ruggedized version of the DMI connector, with all mechanical parts made in Titanium, except the spring clip made in coated CuBe. It is by far the smallest, lightest footprint proposed.

fig. 6 DMI-Space connection (two connectors and a mating adapter)

Full specification will be published by Q1 2011

5 Quality grades

To responds to the various phase, different grades has been defined. Each corresponds to a different quality process and has a different prices.

The prices difference from commercial → enhanced → space grades are 1x → 5x → 10x. This corresponds to termination services only.

5.1 Commercial grade

This process corresponds to a telecom performance and the optical performance are guaranteed over the use in similar conditions. Telecom industry has standardized thoroughly the performance / environment and our datasheet corresponds to those well known qualities.

5.2 Enhanced grade

- custom aging through cycling during production
- laser engraving of connectors
- 25% additional quantity to cover lot rejects.
- lot travel card.

5.3 Space grade

- Product Identification Document (PID) containing
  - Bill of Material
  - Optical performance
  - Screening test adapted to configuration
  - Non-conformance table to qualified product (when available) or customer specification (when provided) and Lot acceptance test suggestion with offer (delta qualification).
- Production and Test Schedule (PTS)
- Certificate of Compliance
- Lot Screening Test report containing
  - Interferrometric report of each connector
  - Parameters values before and after test with pass/failed criteria

6 Conclusion

We presented the different components composing an optical harness and how they are standardized in telecom and space industry.

A procurement procedure has been presented and should be used in order to request the proper grade for termination.

This white paper is published on our website and will be continuously updated with new information on 'this subject. Please note the version number in the bottom left of each page.

Resources

1. *Optical Fiber Assemblies for Space Flight from the NASA Goddard Space Flight Center, Photonics Group,* Melanie N. Ott et al., ISROS 2009
2. *Evaluation test programme for optical fiber connector sets,* ECSS Basic Specification No. 2263010
3. *Gore Flexlite™ 1.2mm* datasheet